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PEAK WIND STATISTICS ASSOCIATED WITH THUNDERSTORMS AT CAPE KENNEDY, FLORIDA

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This research was performed under contract with the Aero-Astrodynamics Lab, MSFC; Mr. S. C. Brown was the technical coordinator.

16. ABSTRACT

Eleven years of Cape Kennedy, Florida hourly peak wind speeds and hourly surface weather observations are analyzed to determine the risks of wind speeds exceeding critical values in any month at Cape Kennedy. The mean and standard deviations of the peak wind occurrences, categorized as thunderstorm and non-thunderstorm, are fitted to a Fisher-Tippet Type I distribution to show the probability of peak wind speeds ≤ any selected value. Results for July indicate that there is a 99% chance that the peak wind speed will be ≤ 38 knots on any given day. However, if it has been predicted with reasonable assurance that a thunderstorm will occur, there is then a 97.5% chance that the peak wind will be ≤ 38 knots and a 99% chance that it will be ≤ 43 knots.

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FOREWORD

This report presents the results of work performed by Lockheed's Huntsville Research & Engineering Center while under subcontract to Northrop Nortronics (NSL PO 5-09287) for the Aero-Astrodynamics Laboratory of Marshall Space Flight Center, Contract NAS8-20082. This task was conducted in response to the requirement of Appendix A-1, Schedule Order 24.

The NASA technical coordinator for this task is Mr. S.C. Brown, S&E-AERO-YT.

SUMMARY

To determine the risks of wind speeds exceeding critical values in any month at Cape Kennedy, Florida, eleven years of hourly-surface weather records were analyzed. The means and standard deviations of the peak wind occurrences categorized as thunderstorm and non-thunderstorm are tabulated. The data are then fitted to a Fisher-Tippet Type 1 distribution to show the probability that the peak wind will be less than or equal to any selected value. An example of the use of the graphs is presented.

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Section 1
INTRODUCTION

For design of aerospace vehicles and their safe operation at Cape Kennedy, the risks of wind speeds exceeding critical values must be known. To understand better the extreme wind occurrences at Cape Kennedy, the peak winds for each day were determined and categorized as to thunderstorm or non-thunderstorm associated. Because the extreme wind that is possible is not often observed, a method must be found to use observed data to predict chances of encountering certain wind speeds.

Eleven years of surface hourly weather records (1957 - 1967 inclusive) were used for the current study. The peak wind in the data is the peak value recorded within 30 minutes of the hour for 30 ft above station elevation (16 ft MSL). The peak wind was considered to be thunderstorm-associated if a thunderstorm was reported during this period. Winds associated with hurricanes and tropical storms were not considered because of their infrequent, seasonal occurrence and because different methods of predicting them were used than for daily or hourly peak winds.

Section 2
ANALYSIS OF PEAK WINDS

The peak winds in various categories were combined and analyzed, and the combinations and statistics tabulated in Table 1. An explanation of the columns will explain the combinations and statistics analyzed.

Column 1 lists individual months, and months grouped generally by season except that November was included with winter months rather than with September and October. The number of thunderstorms in November more closely approximated the number in winter months than in the fall months.

Subsequent columns provide data for the corresponding month. Because the column headings are abbreviated, contents of each column are completely explained. Column 2 is the mean peak wind speed in knots from non-thunderstorm days.

Column 3 is the mean peak wind speed in knots from thunderstorm days. These peak winds may or may not have accompanied the thunderstorm but the peak wind would most certainly have been associated with an unstable atmosphere.

Column 4 is the mean peak wind speed of all days combined. From the nature of the data the peak wind could have been what is commonly referred to as a wind gust.

Column 5 is the daily mean peak wind associated with a thunderstorm. Notice that Column 5 values are always less than Column 3 values, indicating that all daily peaks on thunderstorm days were not recorded concurrently with a thunderstorm observation.

Column 6 includes all winds in Column 5 as well as a peak wind recorded within $1\frac{1}{2}$ hrs of all thunderstorm reports. The winds both an hour before and an hour after a thunderstorm report were used to find the peak wind, but the nature of the data included another $\frac{1}{2}$ hr in the record.

Column 7 used the same thunderstorm reports as Column 6 and the peak wind at the thunderstorm report, therefore the wind would have occurred within $\frac{1}{2}$ hr of the thunderstorm report.

Columns 8 through 13 are the standard deviations of the data used to compute the means in Columns 2 through 7, respectively.

Columns 14 and 15 are the absolute peak wind speeds on non-thunderstorm and thunderstorm days, respectively. The 60 kt peak wind on a non-thunderstorm day in August was associated with a tropical disturbance in the vicinity of Cape Kennedy which did not meet our storm criteria for removal. Although this datum should have been removed, it was left in the data to determine its effect. From Figs. 6, 7, 8 and 9, June, August and September show about 34 kt at 99% and August is about 3 kt higher than July at 99%. It appears that the two large values in August caused the 99% value to be no more than 3 kt higher.

Columns 16 through 21 show the total observations and percent of observations for which previous columns of data were analyzed.

The peak wind data used in Columns 2, 3 and 4 were then fitted to a Fisher-Tippett Type 1 (FT1) distribution by Gumbels, Liebliens and a maximum likelihood method (Ref. 1). Figure 1 shows the data for July peak wind thunderstorm days with computed control bands. Figure 2 shows the data for August peak winds on non-thunderstorm days which was the poorest fit, but the distribution compensated for the high value attributed to the tropical disturbance. All other months showed a good fit to the FT1 distribution. The Fisher-Tippett Type 1 distribution as it is generally recognized is

$$F(y) = e^{-e^{-\alpha(y-\mu)}}$$

$$\alpha = \sigma^{-1}$$

$$\mu = \text{mode} \quad (1)$$

when $\alpha = 1$ and $\mu = 0$.

The data fits a "standard" distribution with a "standard" variable y, and it can be written

$$F(y) = e^{-e^{-y}} \quad (2)$$

There is one independent variable y and one dependent variable F(y). As F(y) ranges from 0.001 to 0.999 y ranges from -2 to 7.

Any independent variable y from a FT1 distribution can be reduced to the "standard" variable by the calculation

$$Z = \alpha(y - \mu) \quad (3)$$

where Z is now the "standard" variable or what Gumbel (Ref. 2) calls the "reduced variate."

For convenience the monthly peak winds for thunderstorm, non-thunderstorm and all days, assuming FT1 distribution, have been plotted in Figs. 3 through 11. November, December, January and February have been combined in one graph because of insufficient thunderstorm days in any one month. The plotting method simplified as in Gumbel is to plot μ vs the reduced variate at 0.

$$\mu = \bar{x} - 0.45\,\sigma$$

$\bar{x}$ = mean, σ = standard deviation.

Then plot $\mu + 2\sigma$ vs the reduced variate at 2.58 (approximate probability of 0.925). The straight line connecting these points represents the FT1 distribution.

The graphs may be used to evaluate the chances of encountering certain peak wind speeds on any day. For example, on any day in July (Fig. 7) there is a 99% chance that the peak wind will be $\leq$ 38 kt. If it has been predicted with reasonable assurance that a thunderstorm will occur, then there is a 97.5% chance that the peak wind will be $\leq$ 38 kt or a 99% chance that the wind will be $\leq$ 43 kt.

All of the graphs possible from Table 1 have not been plotted here but if graphs for other data in Columns 2 through 7 are desired the method shown here can be used.

Section 3
CONCLUSIONS

The data and methods used herein provide an objective procedure to determine the risks involved for various peak wind speeds on any day at Cape Kennedy. The results provide planning information as well as operational information. These data, when used with reports on thunderstorm probability (Refs. 3 and 4) will provide additional information about the chances of peak winds with thunderstorms.

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2. Gumbel, E.J., "Statistics of Extremes," Columbia University Press, 1966.

3. Falls, L.W., "A Probability Distribution for the Number of Thunderstorm Events at Cape Kennedy, Florida," NASA TM X-53816, February 1969.

4. Lee, R.F., J.W. Ownbey, and F.T. Quinlan, "Thunderstorm Persistence at Cape Kennedy, Florida," NASA CR-61259, January 1969.

Table 1

CAPE KENNEDY PEAK WIND ANALYSIS

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
	MEAN WIND SPEED (Knots)						STANDARD DEVIATION						Absolute Peak Wind Speed on (Knots)							
	Peak Wind Non-⛈ Days	Peak Wind ⛈ Days	Peak Wind All Days	Daily Peak ⛈ Wind	Peak Wind ⛈ Hour ± 1 Hour	Peak Wind ⛈ Hour	Peak Wind Non-⛈ Days	Peak Wind ⛈ Days	Peak Wind All Days	Daily Peak ⛈ Wind	Peak Wind ⛈ Hour ± 1 Hour	Peak Wind ⛈ Hour	Non ⛈ Days	⛈ Days	Total No. Days Analyzed	No. Days With ⛈s	% of Days With ⛈s	Total No. of Hourly Observations Analyzed	No. of Hourly Observations With ⛈s	% of Hourly Observations With ⛈s
March	21.5	25.2	21.9	23.1	($\pm 1\frac{1}{2}$ Hour) 21.78	($\pm\frac{1}{2}$ Hour) 17.69	6.0	7.9	6.3	8.5	8.09	7.52	43	46	341	33	9.7	8184	116	1.42
April	20.0	26.5	20.7	23.0	21.85	17.42	4.7	8.3	5.5	10.7	10.01	8.51	39	53	330	33	10.0	7920	78	0.98
May	18.3	20.7	18.8	18.6	16.49	13.14	4.2	4.7	4.4	5.8	6.35	6.37	36	36	341	74	21.7	8184	242	2.96
Spring	20.0	23.2	20.4	20.7	18.85	15.12	5.2	7.0	5.6	8.2	8.05	7.45			1012	140	13.8	24288	436	1.79
June	18.2	20.7	19.3	19.7	17.57	13.75	4.9	6.8	5.9	7.7	7.55	7.09	44	48	330	140	42.4	7920	519	6.55
July	17.7	21.6	19.5	20.8	17.66	13.59	4.3	6.7	5.9	7.3	7.49	7.04	34	45	341	160	46.9	8184	682	8.33
August	16.0	18.7	17.7	18.3	16.31	12.38	5.8	6.1	6.2	7.2	7.11	6.53	60	40	341	157	46.1	8184	573	7.00
Summer	17.3	20.7	18.8	19.6	17.19	13.25	5.1	6.6	6.1	7.4	7.41	6.92			1012	457	45.1	24288	1774	7.30
September	17.9	21.1	18.9	19.2	17.01	13.63	5.5	6.7	6.1	7.1	7.23	7.13	42	43	319	98	30.7	7656	345	4.50
October	19.1	19.6	19.2	17.6	16.81	14.00	5.3	6.1	5.3	6.8	6.30	6.65	34	46	331	31	9.4	7944	94	1.18
Fall	18.6	20.7	19.0	18.8	16.96	13.71	5.4	6.6	5.7	7.1	7.04	7.03			650	129	19.9	15600	439	2.81
November	18.5	22.8	18.6	20.3	17.93	14.59	5.5	3.3	5.5	3.7	5.28	6.40	36	29	330	9	2.7	7920	27	0.03
December	18.9	20.3	19.0	16.7	17.20	14.60	5.8	6.3	5.8	7.6	6.14	7.51	36	33	341	7	2.0	8184	20	0.02
January	20.1	25.5	20.2	23.2	23.36	19.09	6.0	4.3	6.0	3.9	3.67	5.81	45	34	341	6	1.8	8184	11	0.01
February	21.6	26.9	21.9	22.6	21.31	17.38	6.7	4.8	6.7	5.4	6.56	5.40	42	34	310	14	4.5	7440	39	0.05
Winter	19.8	24.4	19.9	21.0	19.75	16.23	6.1	5.4	6.1	5.8	6.26	6.74			1322	36	2.7	31728	97	0.03
Annual	19.2	21.3	19.6	19.7	17.51	13.72	5.7	6.7	6.0	7.5	7.46	7.07	60	53	3986	762	19.1	95904	2746	2.86

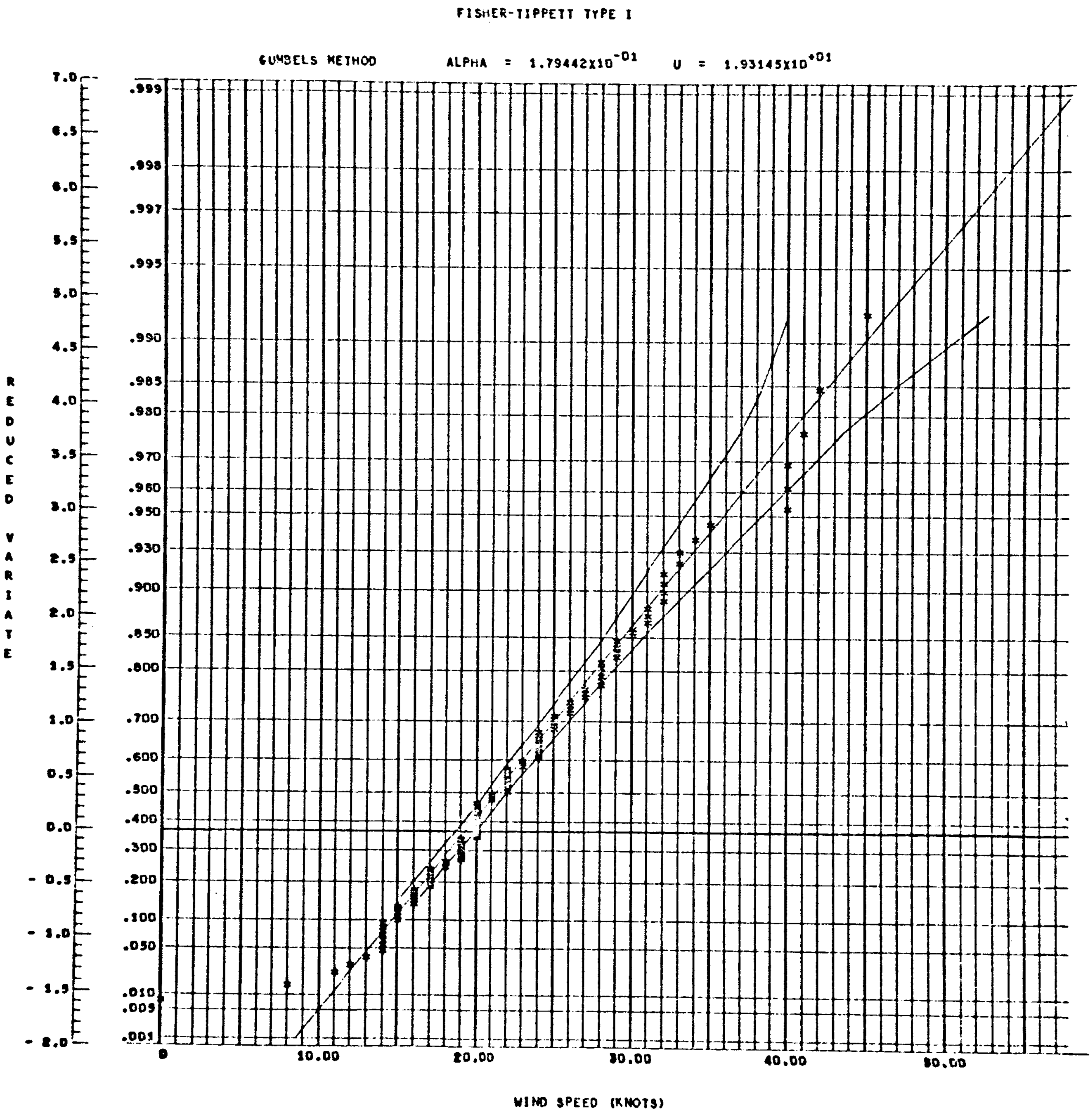

Fig. 1 - Cape Kennedy Daily Peak Winds on Thunderstorm Days, July

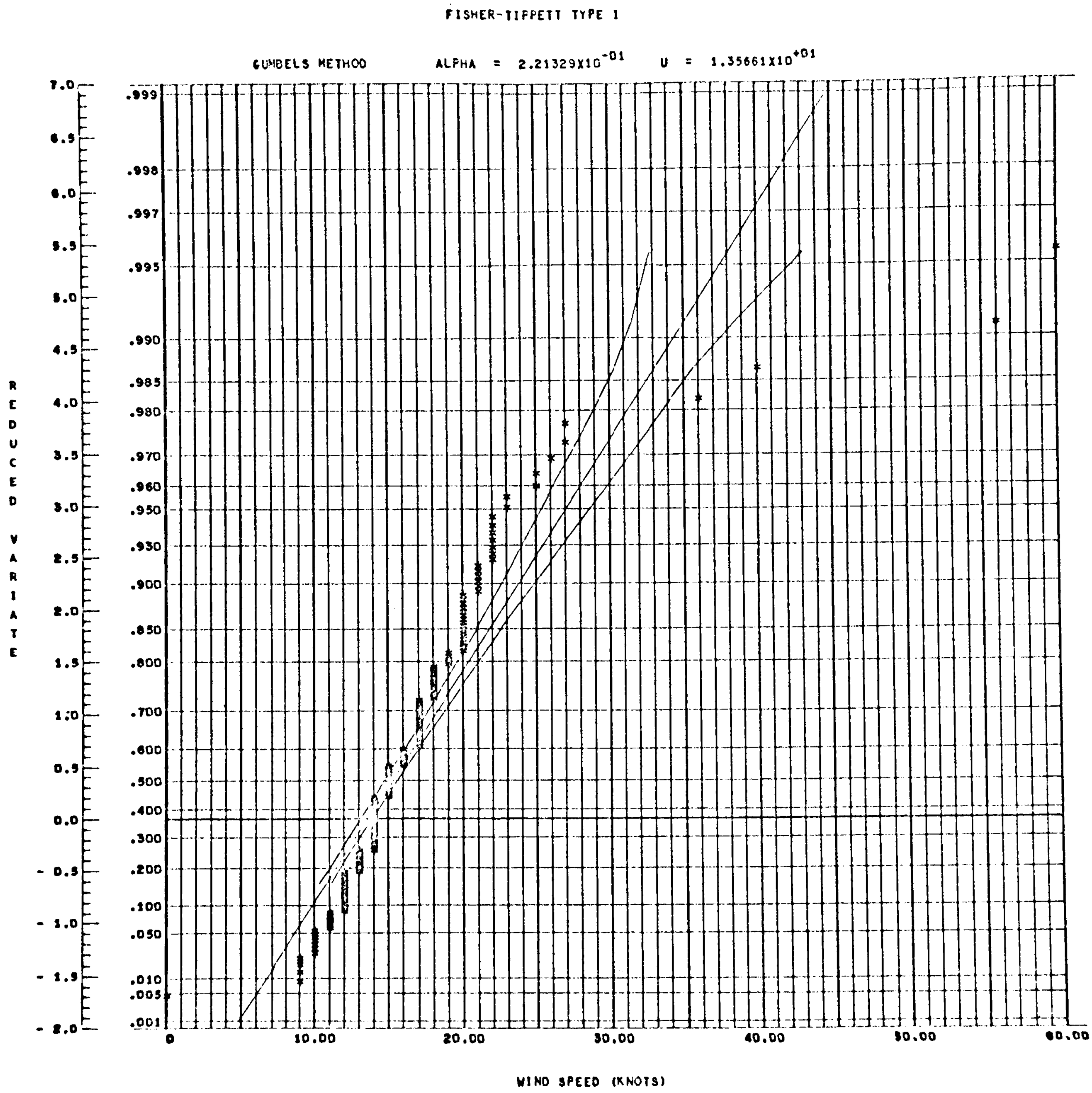

Fig. 2 - Cape Kennedy Daily Peak Winds on Non-Thunderstorm Days, August

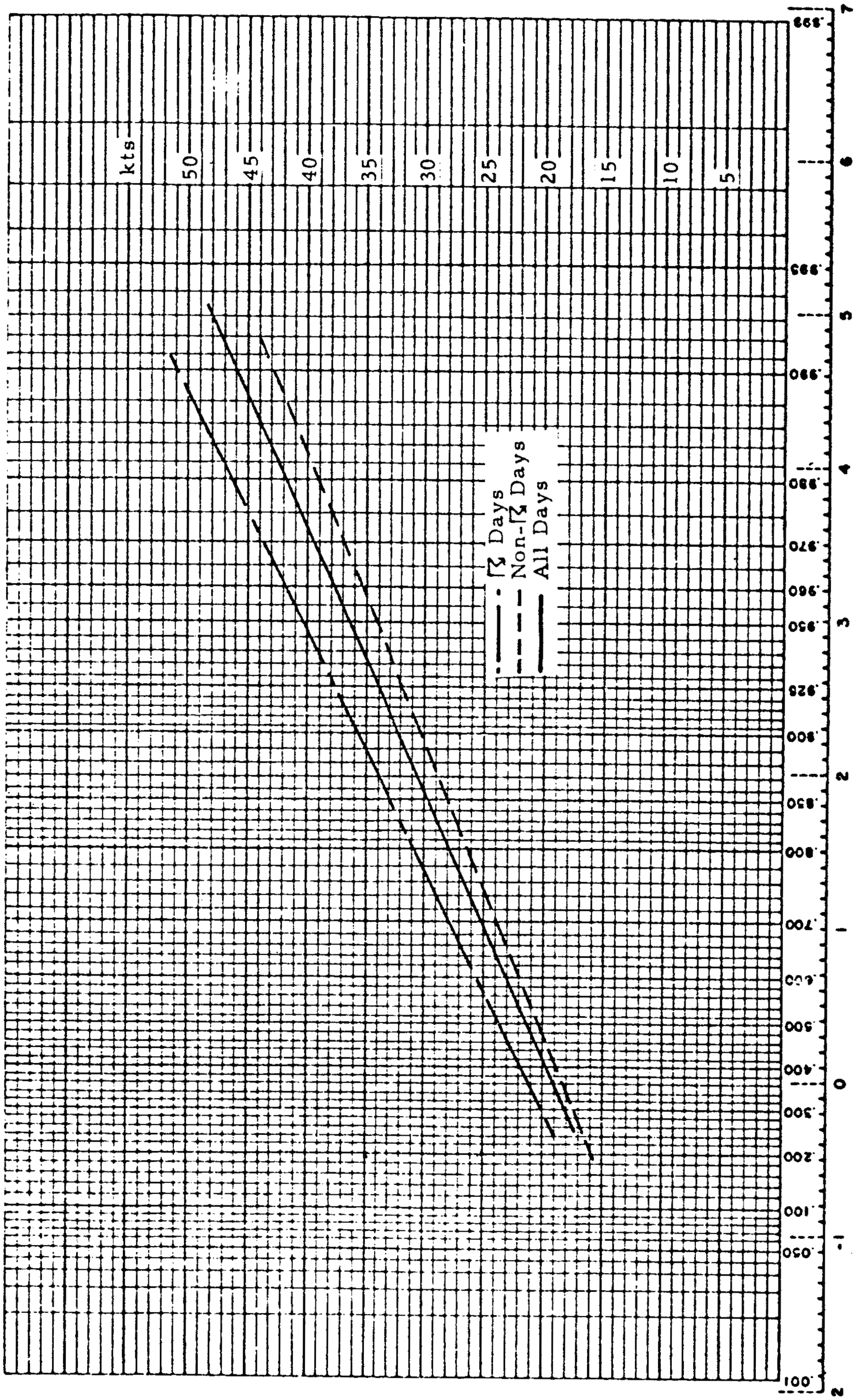

Fig. 3 - Probability of Peak Wind ≤ Speed Indicated, March, Cape Kennedy, Fla.

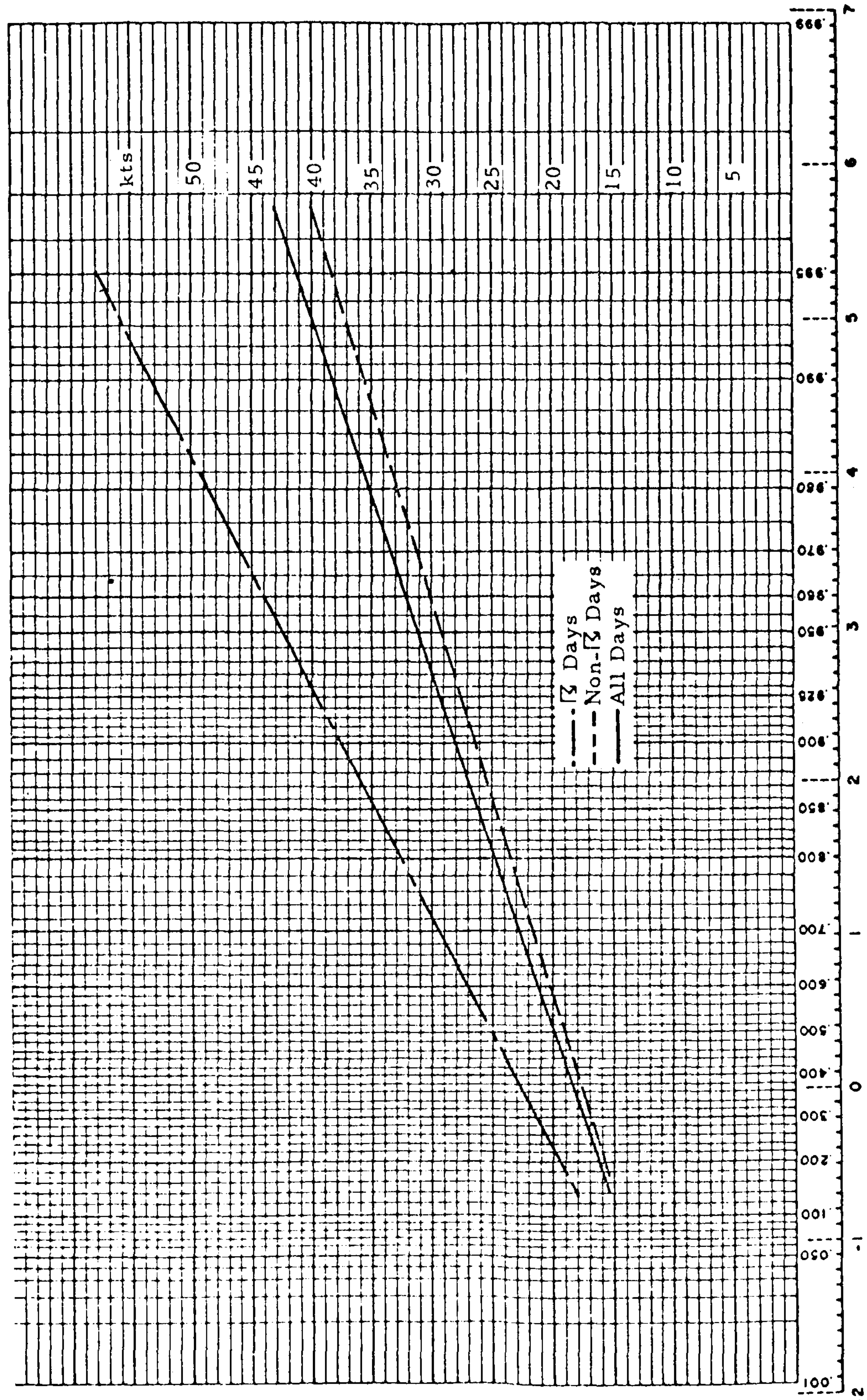

Fig. 4 - Probability of Peak Wind ≤ Speed Indicated, April, Cape Kennedy, Fla.

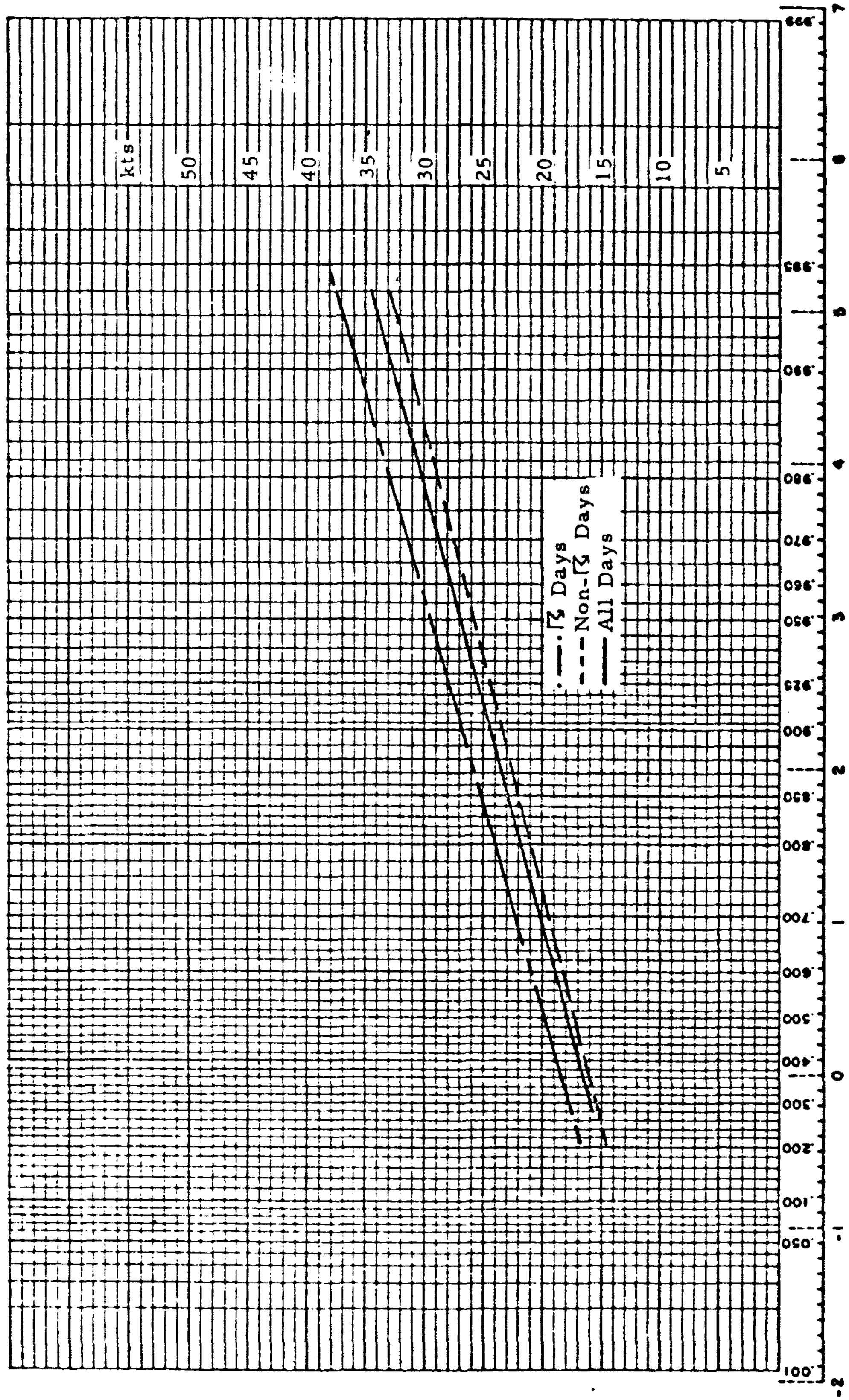

Fig. 5 - Probability of Peak Wind $\leq$ Speed Indicated, May, Cape Kennedy, Fla.

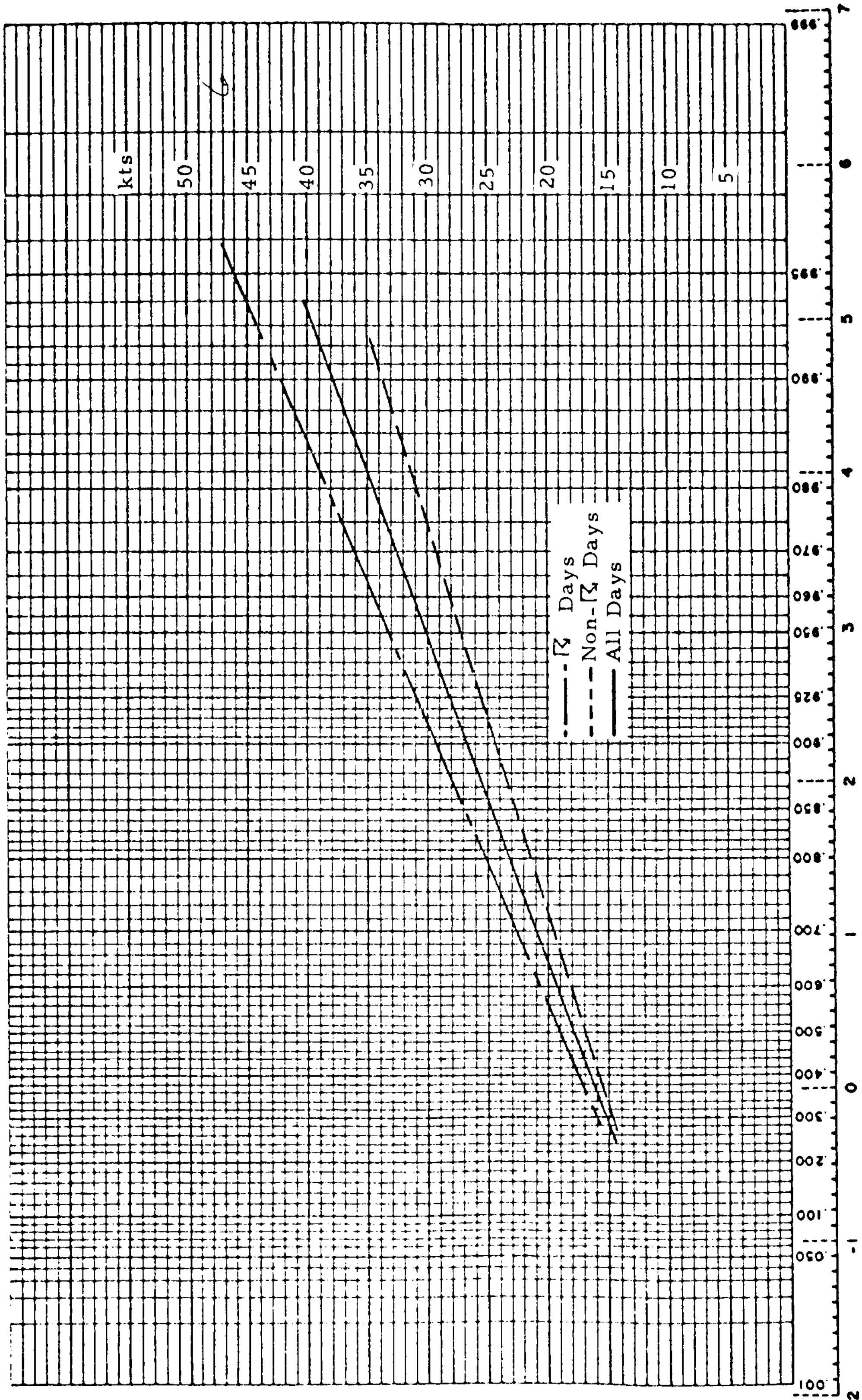

Fig. 6 - Probability of Peak Wind ≤ Speed Indicated, June, Cape Kennedy, Fla.

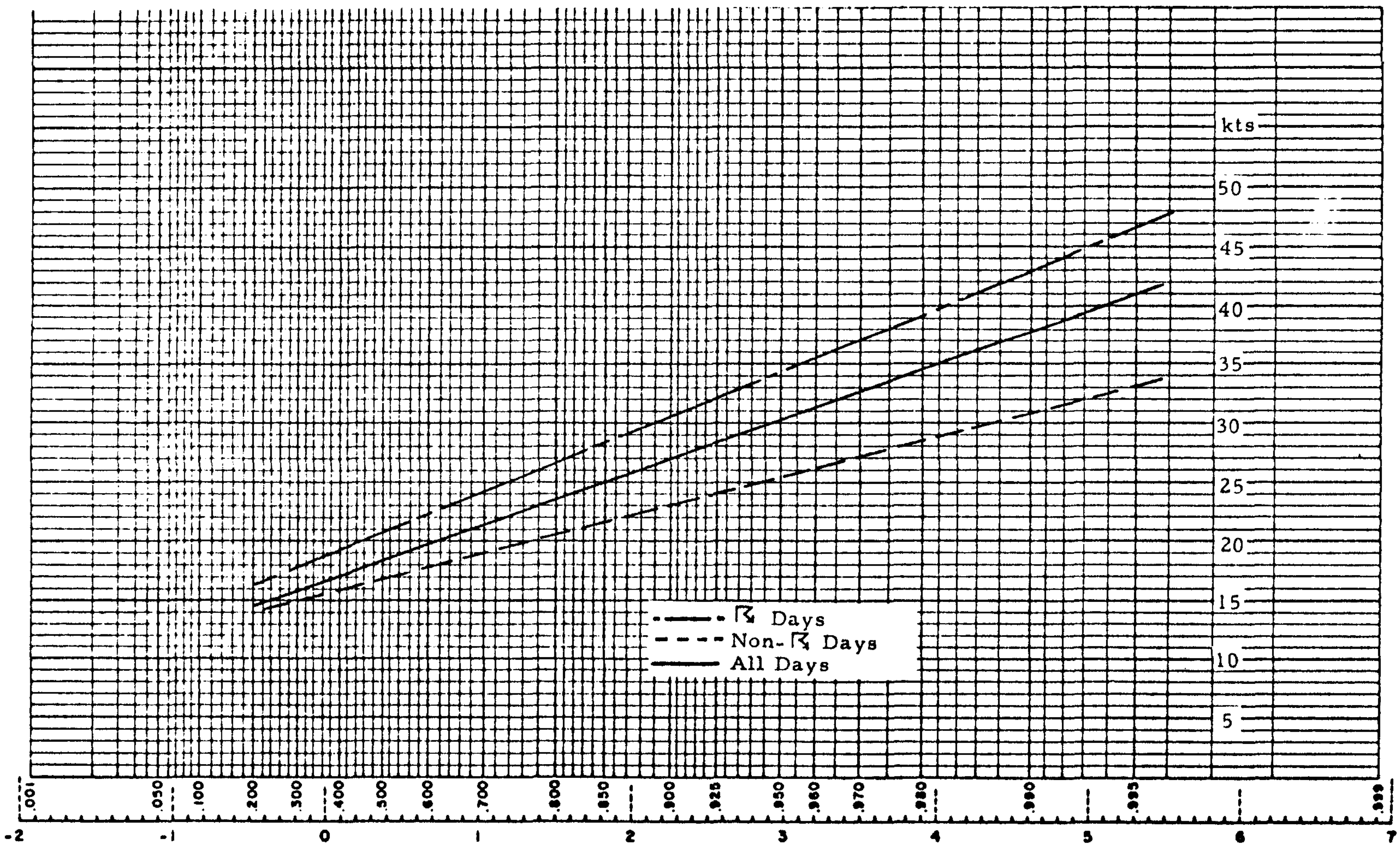

Fig. 7 - Probability of Peak Wind ≤ Speed Indicated, July, Cape Kennedy, Fla.

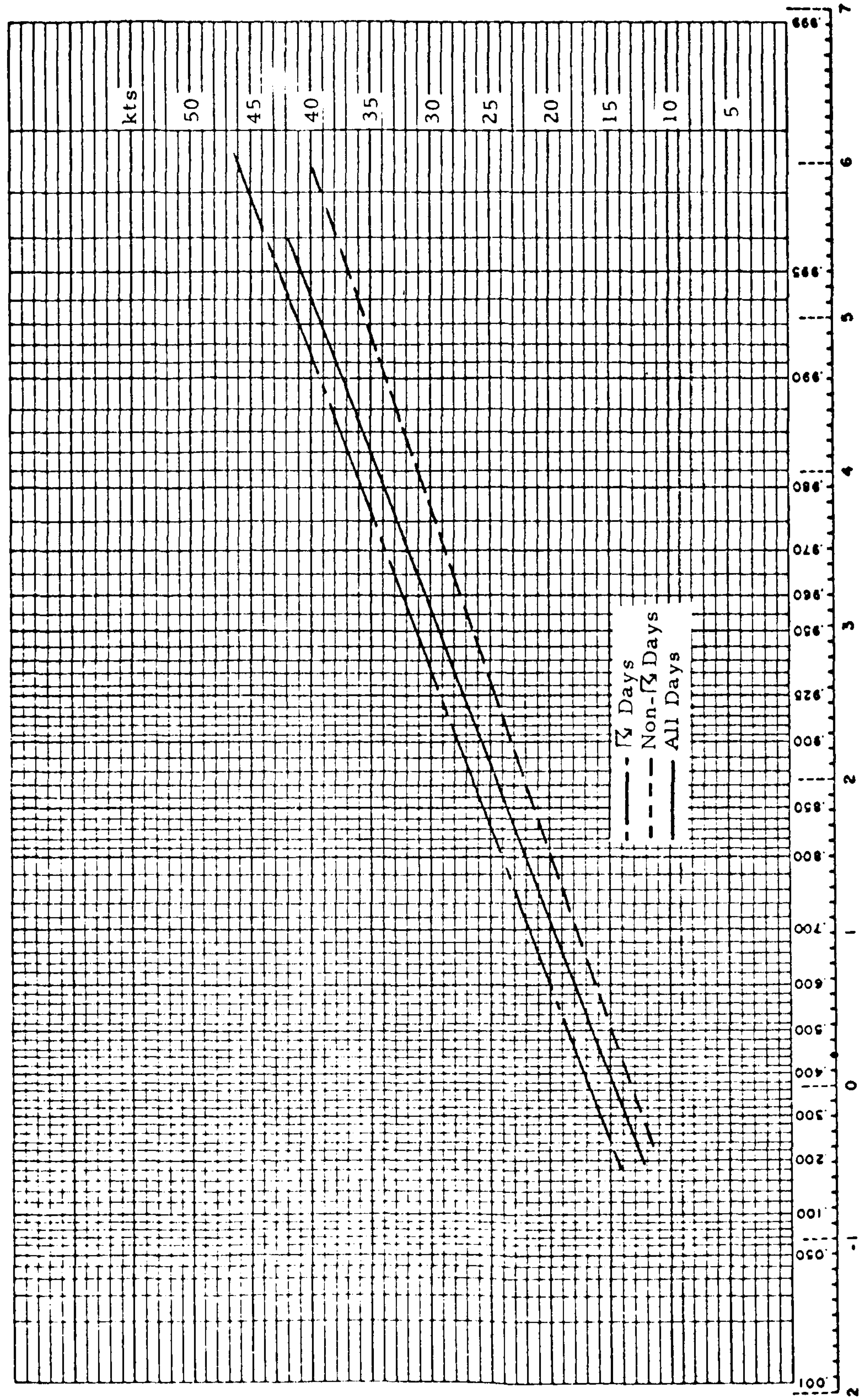

Fig. 8 - Probability of Peak Wind ≤ Speed Indicated, August, Cape Kennedy, Fla.

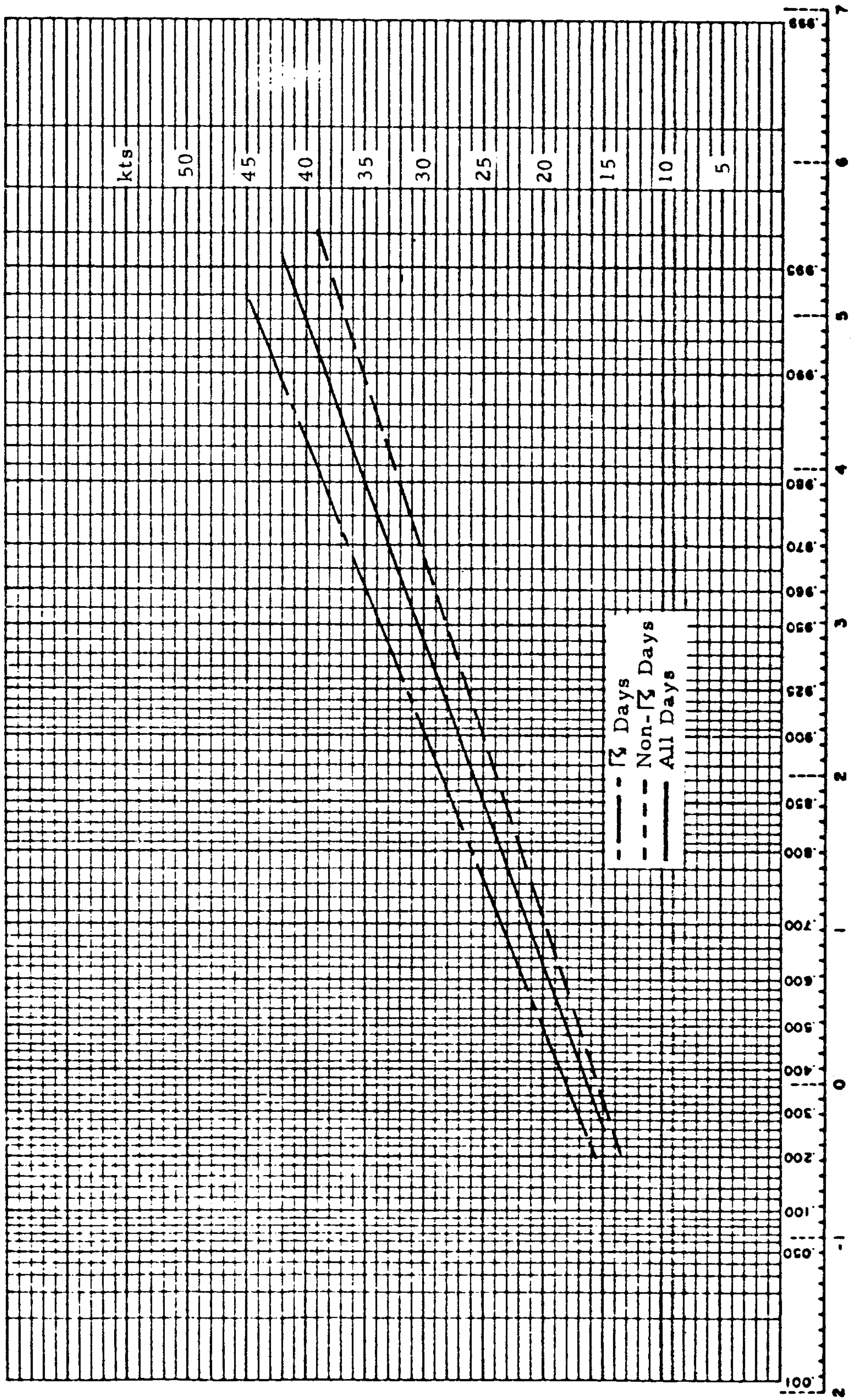

Fig. 9 - Probability of Peak Wind ≤ Speed Indicated, September, Cape Kennedy, Fla.

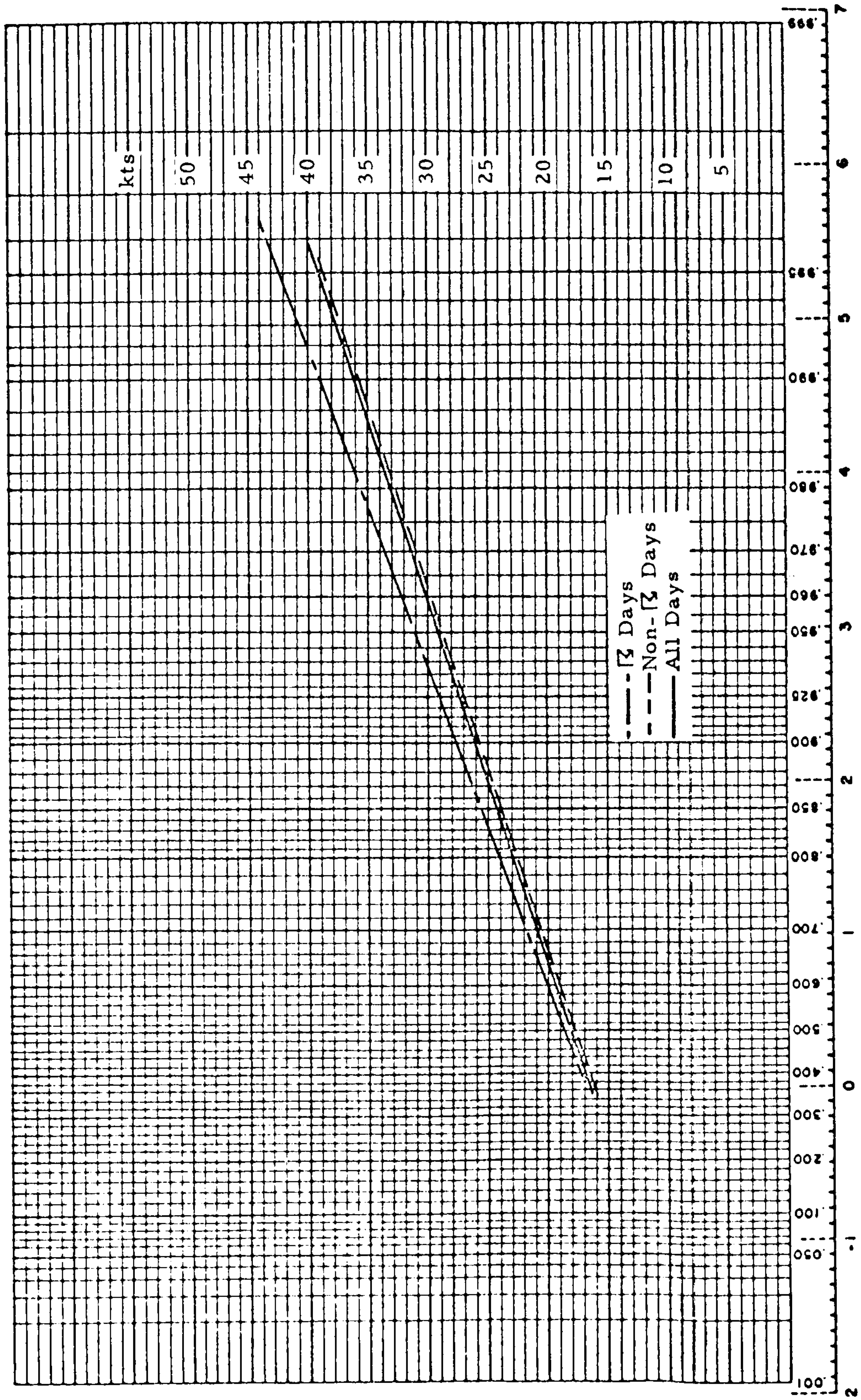

Fig. 10 - Probability of Peak Wind ≤ Speed Indicated, October, Cape Kennedy, Fla.

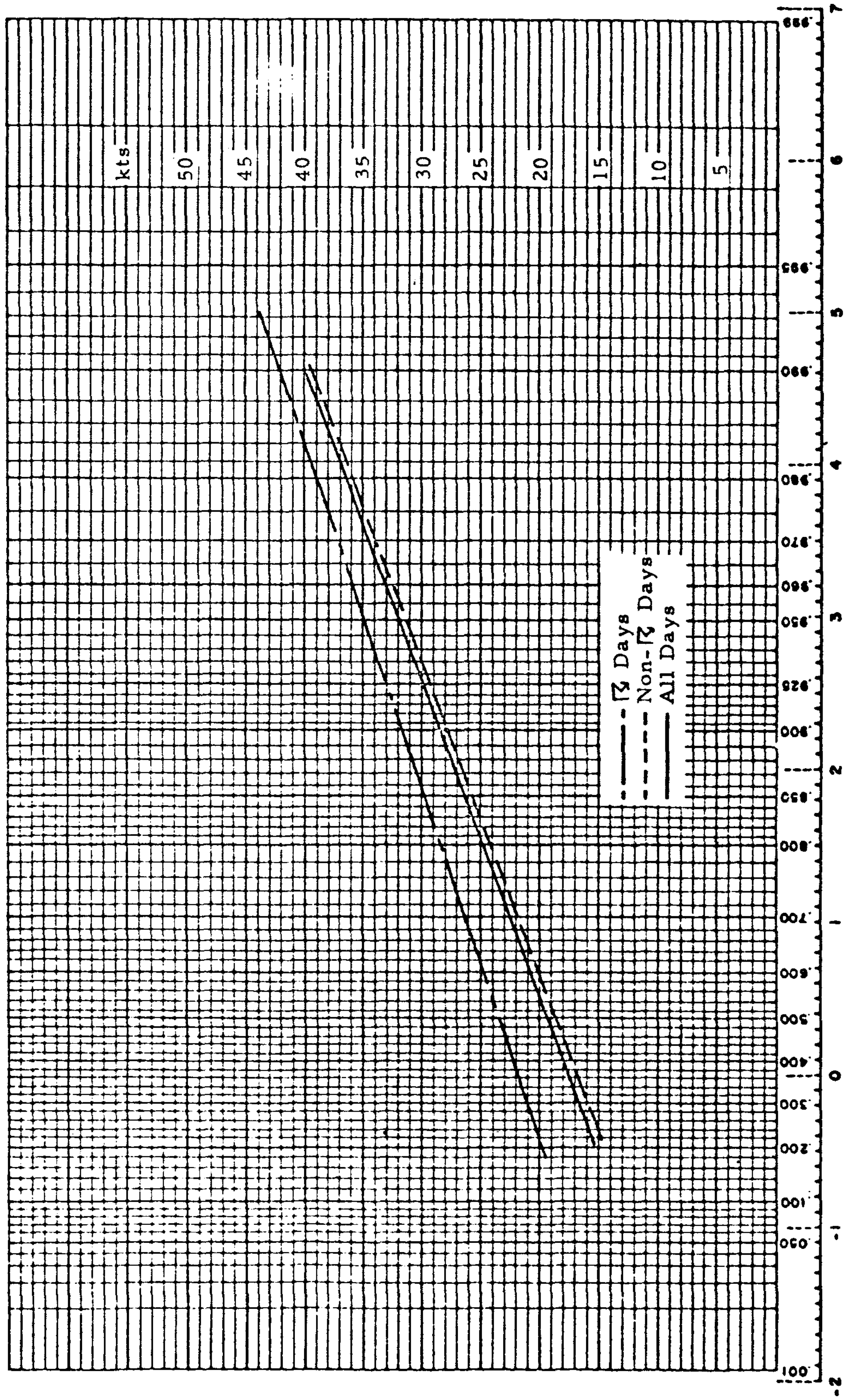

Fig. 11 - Probability of Peak Wind ≤ Speed Indicated, Nov., Dec., Jan., Feb., Cape Kennedy, Fla.